## CLAIMS

What is claimed is:

1. A method of two-stage combustion integrating *in situ* oxygen generation, the method characterized by the steps of:

oxidizing, using an air reactor, a reduced oxygen carrier stream to form an oxidized oxygen carrier stream;

separating, in a primary separator, ~~an~~ oxygen carrier and oxygen-depleted air from the oxidized oxygen carrier stream;

producing, in an oxygen generation system, gaseous oxygen;

combusting, using a primary fuel reactor, fuel in the presence of the oxygen carrier;

combusting, using a secondary fuel reactor, at least one of an additional fuel supply and an unburned fuel exiting the primary fuel reactor in the presence of the gaseous oxygen.

2. The method of Claim 1, wherein the oxidizing comprises oxidizing the reduced oxygen carrier stream using one of a riser reactor and a fluidized bed reactor.

3. The method of any of Claims 1-2, wherein the combusting comprises combusting the fuel using the primary fuel reactor being one of a fluidized bed reactor and a moving bed reactor.

4. The method of any of Claims 1-3, wherein the combusting the at least one of the additional fuel supply and the unburned fuel exiting the primary fuel reactor comprises combusting such a fuel using an oxy-fuel boiler or any type of a combustion chamber.

5. The method of any of Claims 1-4, wherein the producing comprises generating the gaseous oxygen in an ion transport membrane of the oxygen generation system for one of internal use or as a utility.

6. The method of Claim 5, wherein the generating the gaseous oxygen in the ion transport membrane comprises separating oxygen from the oxygen-depleted air leaving the primary separator.

7. The method of any of Claims 1-6, wherein the producing comprises generating the gaseous oxygen in an oxygen generation reactor of the oxygen generation system for one of internal use or as a utility.

8. The method of Claim 7, wherein the oxygen carrier leaving the primary separator enters at least one of the primary fuel reactor, the oxygen generation reactor, and the secondary fuel reactor.

9. The method of Claim 7, wherein the producing comprises generating the gaseous oxygen in the oxygen generation reactor by at least one of increasing pressure of the oxygen generation reactor, adjusting the oxygen generation reactor temperature, and injecting a sweep gas, the sweep gas selected from the group consisting of carbon dioxide and steam, in the presence of the oxygen carrier.

10. The method of Claim 9, further characterized by the step of:

separating, in a secondary separator, the gaseous oxygen and the oxygen carrier.

11. A system for two-stage combustion integrating *in situ* oxygen generation, the system characterized by:

an air reactor configured to oxidize a reduced oxygen carrier stream to form an oxidized oxygen carrier stream;

a primary separator configured to separate ~~an~~ oxygen carrier and oxygen-depleted air from the oxidized oxygen carrier stream;

an oxygen generation system configured to produce gaseous oxygen;

a primary fuel reactor configured to combust fuel in the presence of the oxygen carrier; and

a secondary fuel reactor configured to combust at least one of an additional fuel supply and an unburned fuel exiting the primary fuel reactor in the presence of the gaseous oxygen.

12. The system of Claim 11, wherein the air reactor comprises one of a riser reactor and a fluidized bed reactor.

13. The system of any of Claims 11-12, wherein the primary fuel reactor comprises one of a fluidized bed reactor and a moving bed reactor.

14. The system of any of Claims 11-13, wherein the secondary fuel reactor further comprises an oxy-fuel boiler or any type of a combustion chamber.

## CLAIMS

What is claimed is:

1. A method of two-stage combustion integrating *in situ* oxygen generation, the method characterized by the steps of:

oxidizing, using an air reactor, a reduced oxygen carrier stream to form an oxidized oxygen carrier stream comprising an oxygen carrier;

separating, in a primary separator, the oxygen carrier and oxygen-depleted air from the oxidized oxygen carrier stream;

producing, in an oxygen generation system, gaseous oxygen, wherein the gaseous oxygen is operable to be produced by separating oxygen from the oxygen-depleted air by using an ion transport membrane, and is operable to be produced by oxygen released from the oxygen carrier having a Chemical Looping Oxygen Coupling (CLOU) effect;

combusting, using a primary fuel reactor, fuel in the presence of the oxygen carrier;

combusting, using a secondary fuel reactor, at least one of an additional fuel supply and an unburned fuel exiting the primary fuel reactor in the presence of the gaseous oxygen produced in the oxygen generation system, wherein the secondary fuel reactor is further operable to have conveyed to the secondary fuel reactor the oxygen carrier from the air reactor.

2. The method of Claim 1, wherein the oxidizing comprises oxidizing the reduced oxygen carrier stream using one of a riser reactor and a fluidized bed reactor.

3. The method of any of Claims 1-2, wherein the combusting comprises combusting the fuel using the primary fuel reactor being one of a fluidized bed reactor and a moving bed reactor.

4. The method of any of Claims 1-3, wherein the combusting the at least one of the additional fuel supply and the unburned fuel exiting the primary fuel reactor comprises combusting such a fuel using an oxy-fuel boiler or any type of a combustion chamber.

5. The method of any of Claims 1-4, wherein the producing comprises generating the gaseous oxygen in an ion transport membrane of the oxygen generation system for one of internal use or as a utility.

6. The method of Claim 5, wherein the generating the gaseous oxygen in the ion transport membrane comprises separating oxygen from the oxygen-depleted air leaving the primary separator.

7. The method of any of Claims 1-6, wherein the producing comprises generating the gaseous oxygen in an oxygen generation reactor of the oxygen generation system for one of internal use or as a utility.

8. The method of Claim 7, wherein the oxygen carrier leaving the primary separator enters at least one of the primary fuel reactor, the oxygen generation reactor, and the secondary fuel reactor.

9. The method of Claim 7, wherein the producing comprises generating the gaseous oxygen in the oxygen generation reactor by at least one of increasing pressure of the oxygen generation reactor, adjusting the oxygen generation reactor temperature, and injecting a sweep gas, the sweep gas selected from the group consisting of carbon dioxide and steam, in the presence of the oxygen carrier.

10. The method of Claim 9, further characterized by the step of:

separating, in a secondary separator, the gaseous oxygen and the oxygen carrier.

11. A system for two-stage combustion integrating *in situ* oxygen generation, the system characterized by:

an air reactor configured to oxidize a reduced oxygen carrier stream to form an oxidized oxygen carrier stream, the oxidized oxygen carrier stream comprising an oxygen carrier;

a primary separator configured to separate the oxygen carrier and oxygen-depleted air from the oxidized oxygen carrier stream;

an oxygen generation system configured to produce gaseous oxygen, wherein the gaseous oxygen is operable to be produced by separating oxygen from the oxygen-depleted air by using an ion transport membrane, and is operable to be produced by oxygen released from the oxygen carrier having a Chemical Looping Oxygen Coupling (CLOU) effect;

a primary fuel reactor configured to combust fuel in the presence of the oxygen carrier; and

a secondary fuel reactor configured to combust at least one of an additional fuel supply and an unburned fuel exiting the primary fuel reactor in the presence of the gaseous oxygen produced in the oxygen generation system, wherein the secondary fuel reactor is further operable to have conveyed to the secondary fuel reactor the oxygen carrier from the air reactor.

12. The system of Claim 11, wherein the air reactor comprises one of a riser reactor and a fluidized bed reactor.

13. The system of any of Claims 11-12, wherein the primary fuel reactor comprises one of a fluidized bed reactor and a moving bed reactor.

14. The system of any of Claims 11-13, wherein the secondary fuel reactor further comprises an oxy-fuel boiler or any type of a combustion chamber.